Center for Integrated Nanotechnologies (CINT)

"Providing the Scientific Basis for Nanomaterials Performance and Integration"

Objectives:

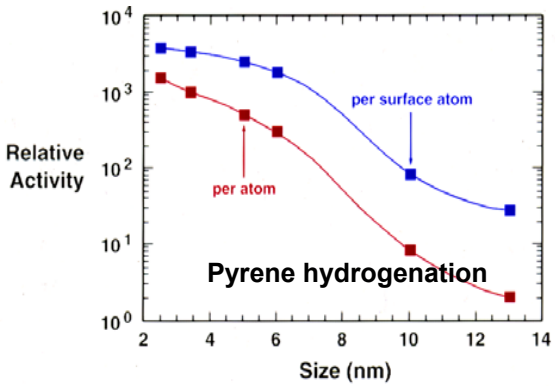
- Develop the scientific principles that govern the performance and integration of nanoscale materials
- Provide a National Resource for training a new generation of researchers in nanoscience and nanotechnology

Building the foundations for integrated nanotechnologies

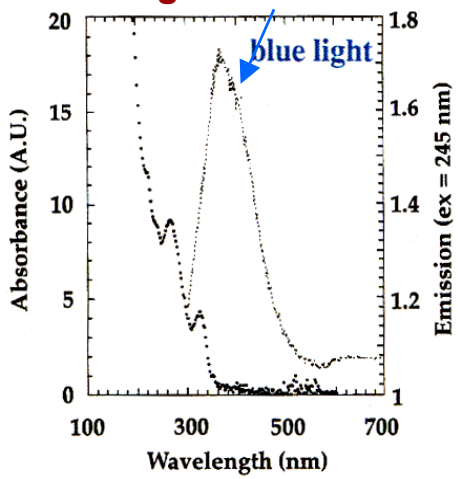
Behavior of materials at the nanoscale is *Nothing* like that at the large scale.

- Properties not predictable from those at large scale
- **New phenomena associate with:**
  - Preponderance of surfaces and interfaces
  - Quantized effects

Catalysis from Pd clusters



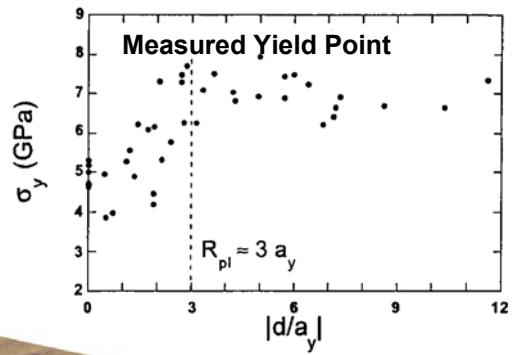
Light from Si

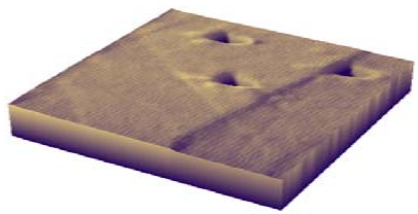


Lead to:

- New modes of electronic and thermal transport
- Collective phenomena
- New chemical reactivities
- New mechanical properties--strength, friction, wear

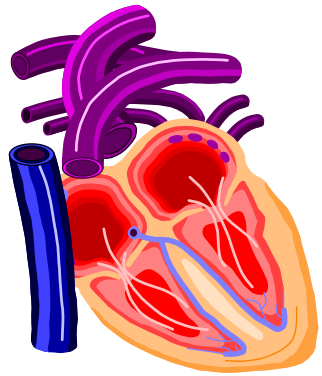
GPa strength from Au



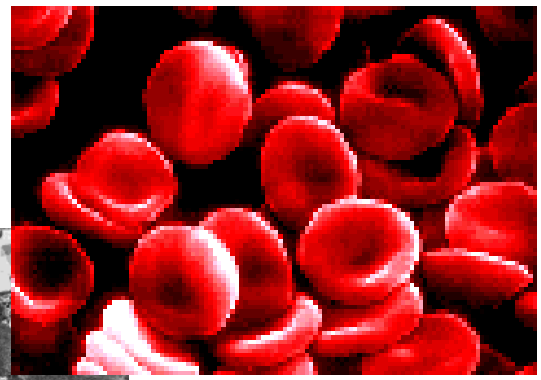


Living systems use Nanotechnology to achieve micro- and macro- function.

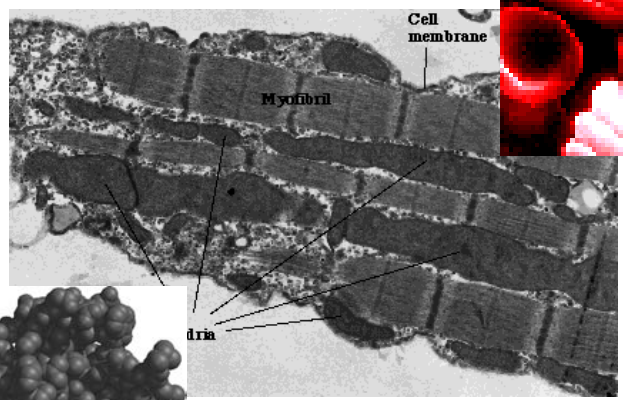
Integrated structures combine multiple length scales and functions.



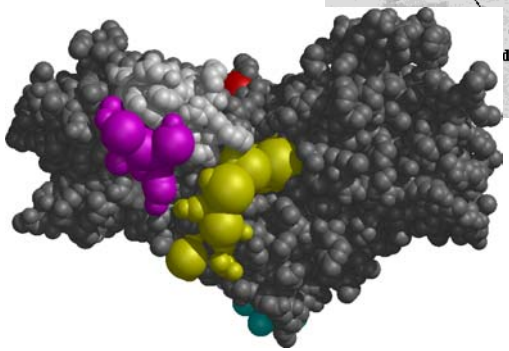
Organs and Tissues



Cells



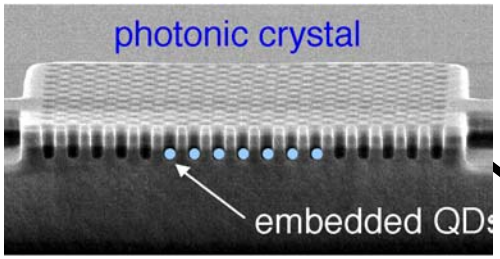
Sub-cellular mechanical structure



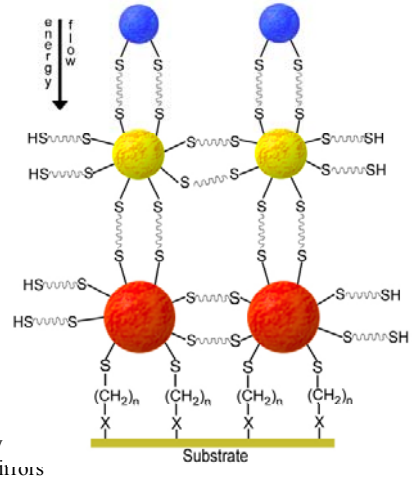
Molecules and Chemical Pathways

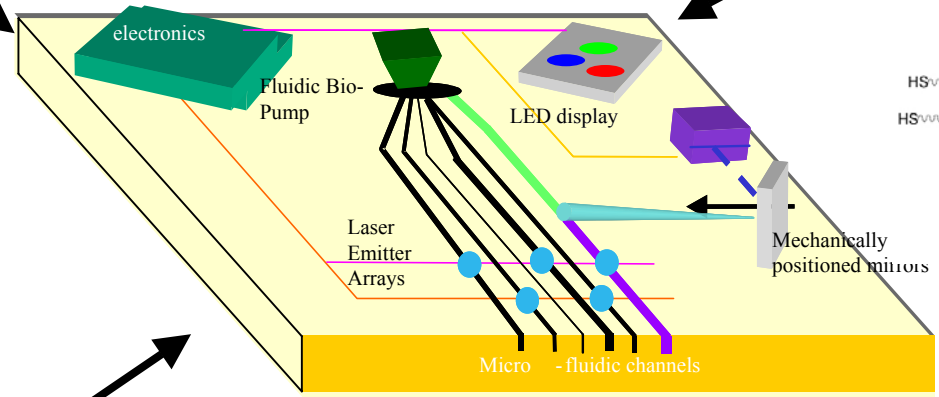
New nanoscience discoveries will have impact via micro and macro scales.

Nanophotonics/Nanoelectronics

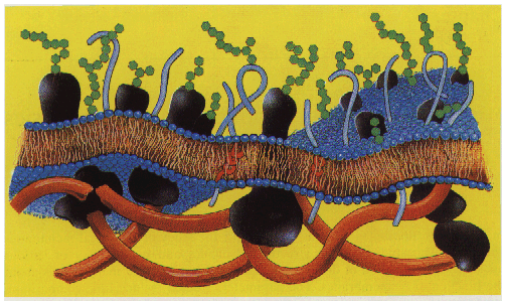


Complex Functional Materials





Nano-Bio-Micro Interfaces



Nanomechanics

CINT's scientific thrusts capitalize on the expertise and capabilities of Los Alamos and Sandia

Nanoscale integration is a scientific challenge of the highest order

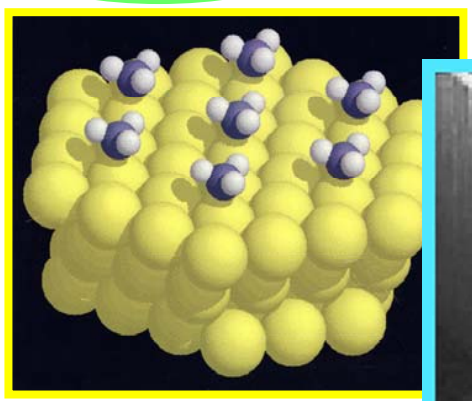
- Developing/understanding the principles that govern assembly and lead to desired functionality.
- Understanding the physics of complex and collective behavior at the nanoscale
  - New properties via quantum confinement, tailored interactions and wavefunction interference
  - Conditions leading to collective effects
- Understanding and controlling interfaces.
  - Transport and transduction across interfaces
  - Interfaces between biological and non-biological entities
  - Need for interconnect strategies
- Developing the tools to characterize properties at the nanoscale
  - Need for novel measurement approaches

Vision

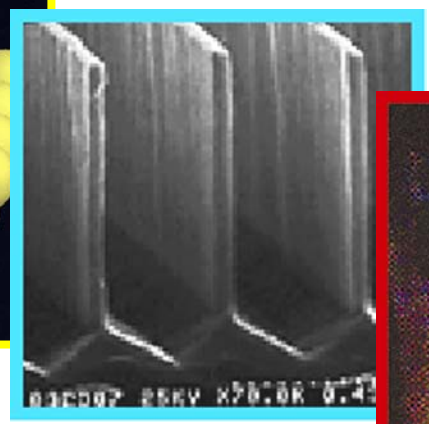
The Center for Integrated Nanotechnologies

Exploring the path from scientific discovery to the integration of nanostructures into the micro/macro world

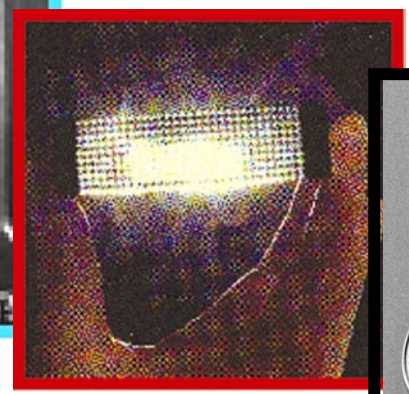
Exploration ⟷ **Discovery** ⟷ **Design**



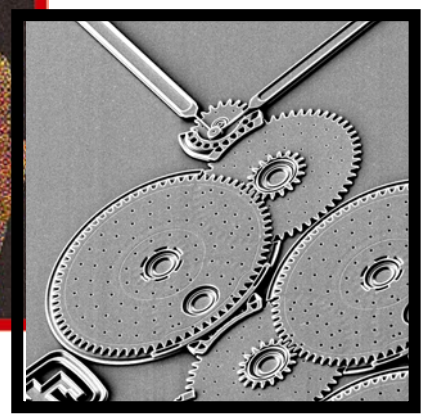
Theory & Experiment



Synthesis & Processing

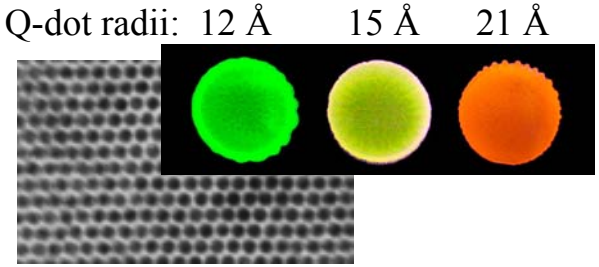


Performance

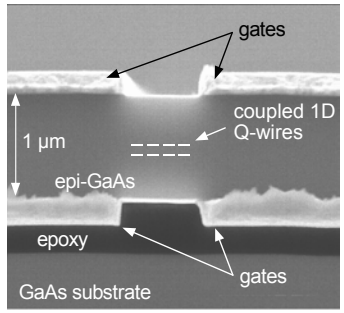


Integration

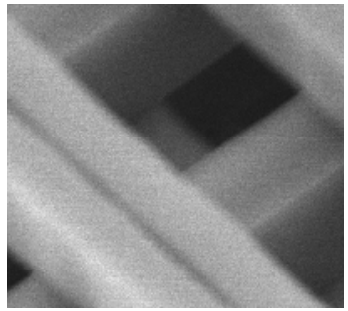
Nanoelectronics & Nanophotonics:
Precise control of electronic and photonic wavefunctions to invoke novel and unique properties



Tunable electronic spectra in Q-dot solids

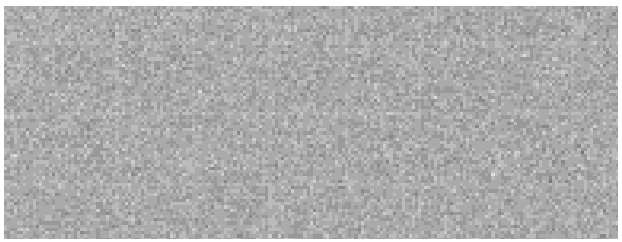


Correlated states in coupled Q-wires

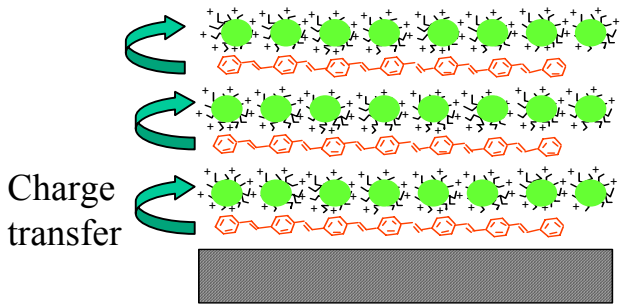


Tunable photon states in photonic structures

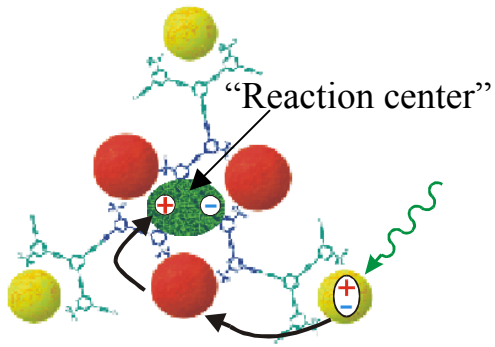
CINT Focus: New Phenomena ⟷ New Nanoscale Materials



Interplay between tunable electronic and photonic spectra



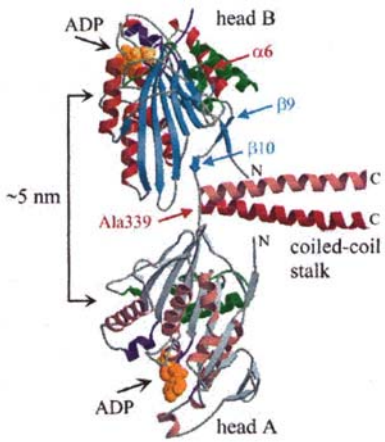
Organic/inorganic hybrid structures



Bio-inspired photonic structures

Nano-Bio-Micro Interfaces:
Biological principles and functions imported into artificial bio-mimetic nano-and microsystems

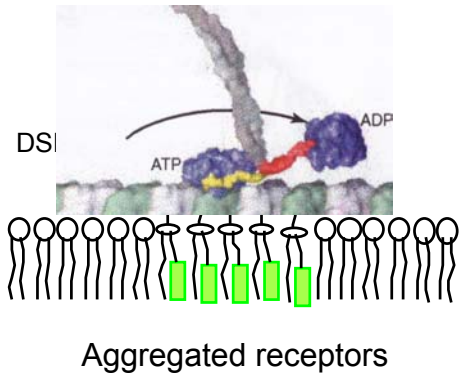
motor proteins



1-10 nm

molecular biology
genetic engineering

biomimetic interfaces

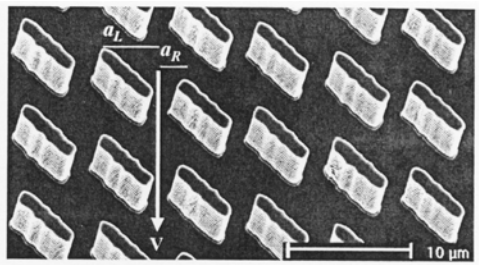


Aggregated receptors

10 -100 nm

complexation chemistry
molecular modeling
self-assembly

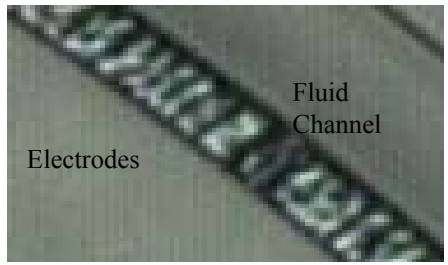
fiber guides and activation systems



10^2-10^4 nm

solid state physics
microfabrication
nanomechanics

microfluidics



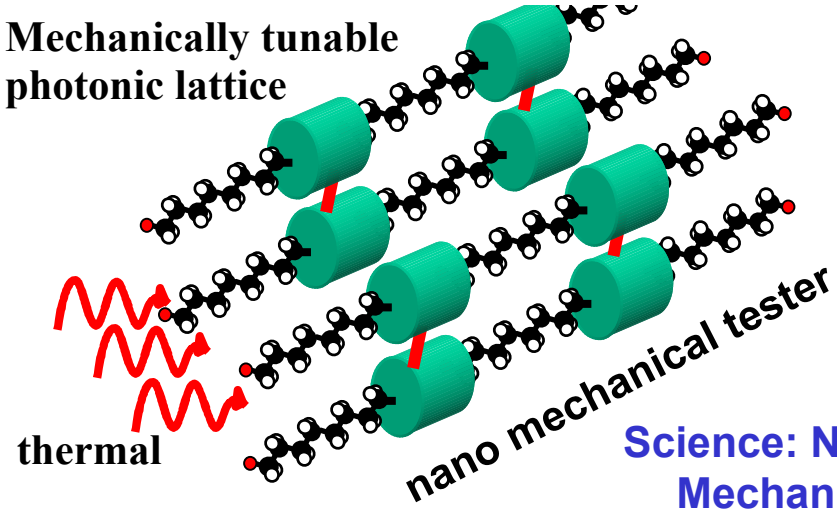
10^5-10^6 nm

fluid mechanics
micromechanics
biochemistry

CINT promotes the development of tailored nanomaterials and the scientific infrastructure required to integrate such materials into functional systems.

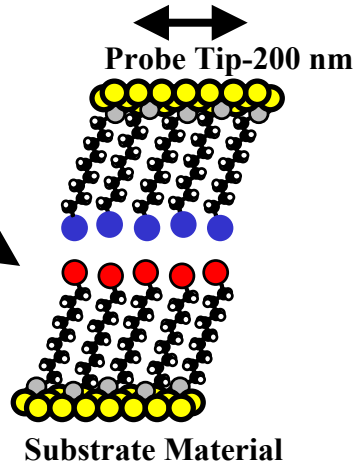
Nanomechanics:
Understanding of the underlying mechanisms of mechanical behavior of nanostructured materials

Future Nano-Machines: Test Materials & Perform Work

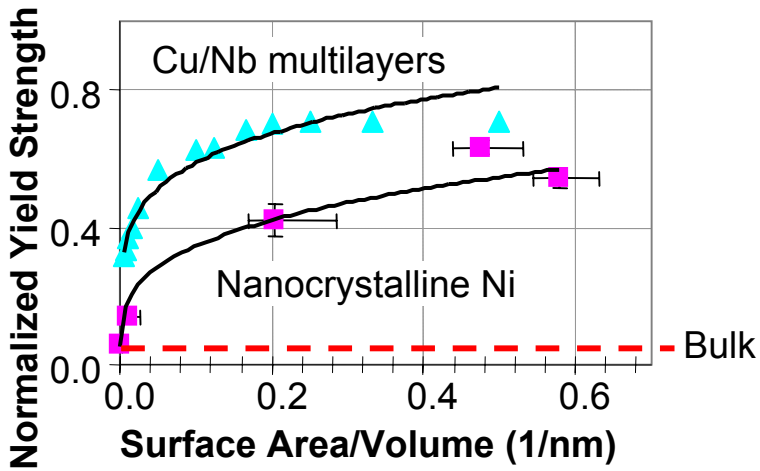


Tool Development: Interfacial Force Microscope

Molecular Tribology of Self-Assembled Monolayers

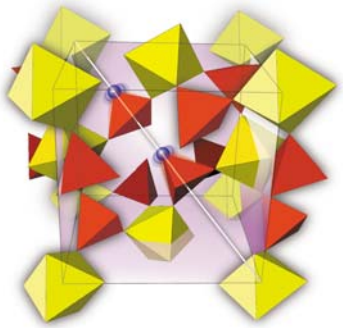


Science: New Deformation Mechanisms for High Interface/ Volume Ratio



Complex Functional Materials:
Promote complex and collective interactions to yield emergent properties and functions

Many materials with unique functionality have complex crystal structures

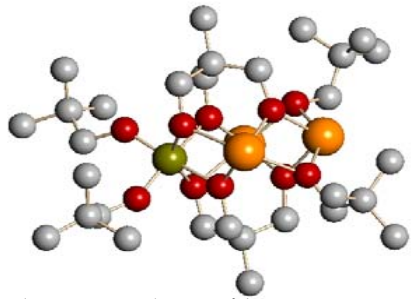


Nanometer Unit Cell- ZrW_2O_8

Underconstrained lattice

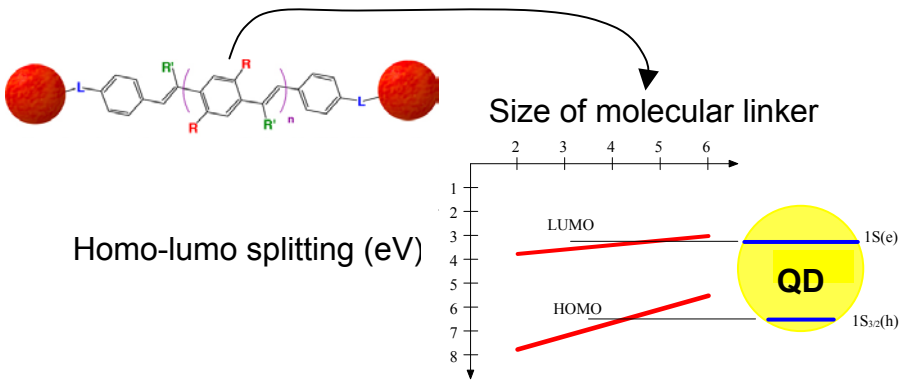
Negative Thermal Expansion

Novel precursor chemistries enable complex materials synthesis

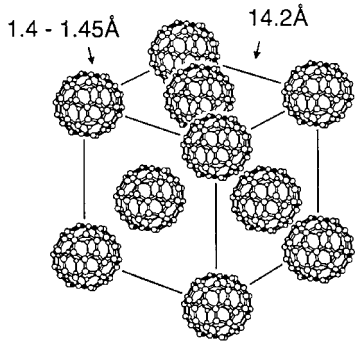


$(m\text{-}THME)Sn_3Ti(m\text{-}ONep)_2(ONep)_2$

Tuning the Quantum Dot-Molecule Interface



New electronic materials enable new functionality



Nanometer Unit Cell

C_{60} Curvature

Superconductivity

LANL, SNL have Core Scientific Staff to support our Scientific Thrust Areas.

Nanophotonics/Nanoelectronics

SNL	LANL
Jerry Simmons	Victor Klimov
Mike Sinclair	Toni Taylor
Mike Lilly	Darryl Smith
John Reno	Stuart Trugman
Shawn Lin	Chris Hammel

Complex Functional Materials

SNL	LANL
Duane Dimos	Art Ramirez
Jeff Brinker	Victor Klimov
Frank van Swol	Sasha Balatsky
Jim Martin	John Sarrao
Jun Liu	Joe Thompson

Nano-Bio Interfaces

SNL	LANL
Bruce Bunker	Andy Shreve
George Bachand	Atul Parikh
Darryl Sasaki	Richard Keller
Paul Gourley	Peter Goodwin
John Shelnutt	Hsing-Lin Wang

Nanomechanics

SNL	LANL
Charles Barbour	Harriet Kung
Jack Houston	Mike Nastasi
Sam Myers	Amit Misra
Liz Holm	Richard Hoagland
Dave Follstaedt	Brad Holian

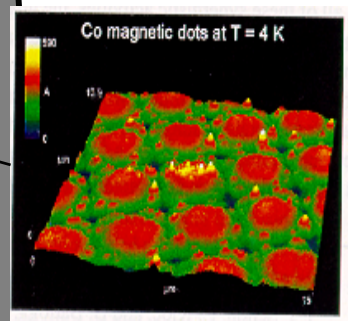
Support staff will be hired to work with research staff and users in operating and maintaining fabrication, characterization equipment.

National Laboratories in New Mexico have key nanoscience capabilities.

User Facilities

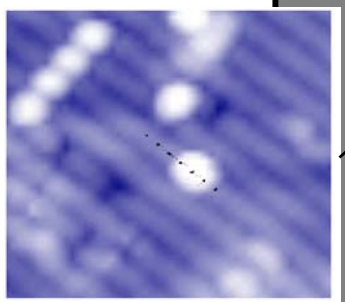
Los Alamos

Sandia



Micro-Fabrication

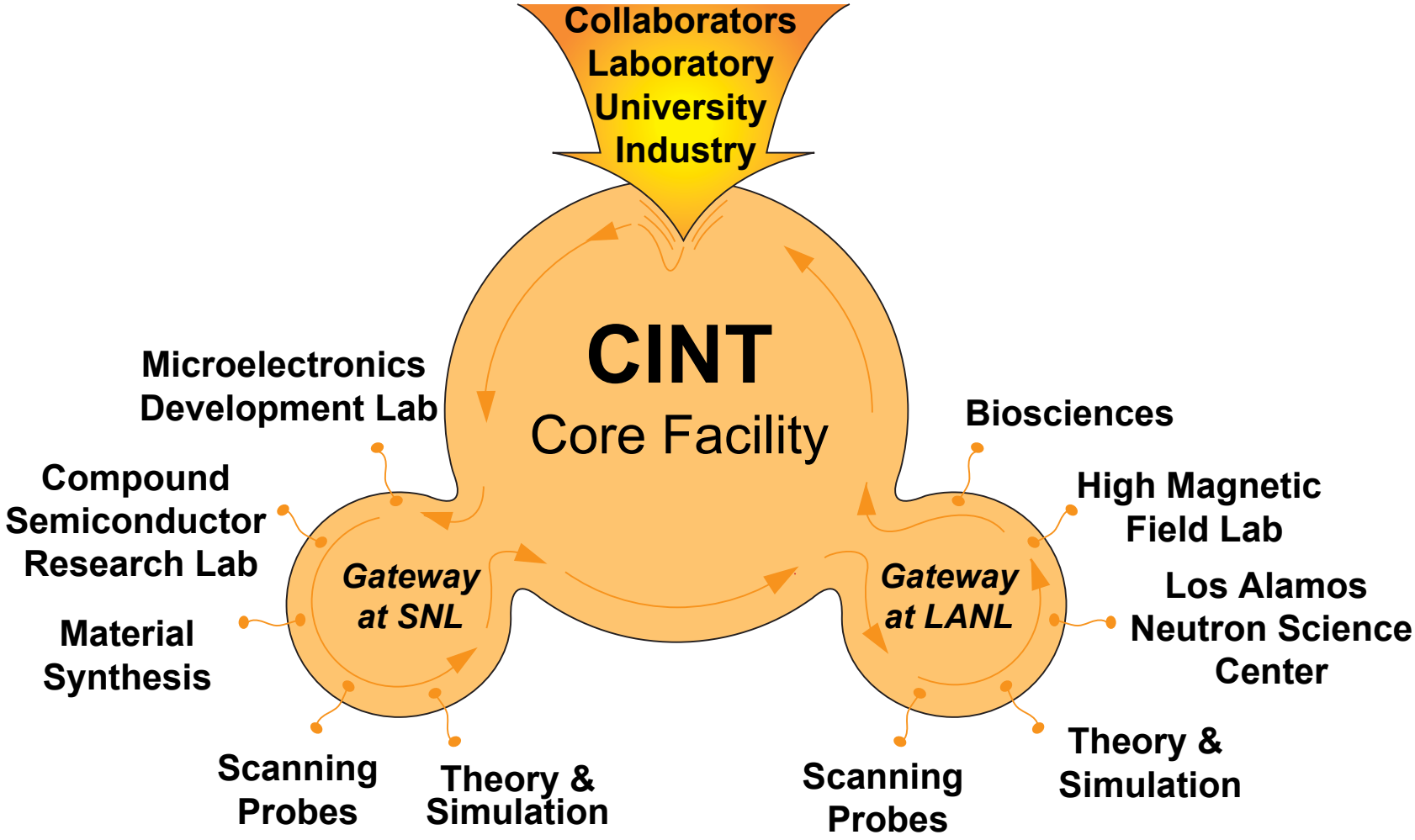
Materials Science



Materials Science

High Performance Computing

Goal: Form one scientific community focused on nanoscience integration.



We are early in our planning – your input will make CINT a valuable national resource

- **DOE has authorized $50 - $85M for construction**
  - Build Core Facility in Albuquerque ~$45M-$50M
  - Use existing building for CINT Gateway at Sandia
  - Combination of existing space and new construction for CINT Gateway at Los Alamos ~ $15M-$20M
  - Lab management supports existing space utilization
- **Community of scientists**
  - Core of CINT scientists (existing & new) ~ 50 - 70
  - Postdocs ~ 40
  - Students ~ 40
  - University/Industry/Laboratory researchers ~ 100
- **Operation and Management**
  - Operation budget ~19M
  - Joint National Laboratory Management
- **Leverage large institutional capabilities**
  - Provide access for CINT participants

Core Facility has equipment and experts needed to incubate projects involving multiple length-scales and disciplines.

Office Suite
Staff, Visitor Accommodations
Computer Bays
Communication Links
15,000 ft²

Synthesis Wing:
(Negative pressure)
Hoods, benches, equipment to handle chemical, biological materials
Bench-top characterization
15,000 ft²

Interaction Areas and Conference Rooms
5,000 ft²

Characterization Wing:
(Vibration Isolation)
Scanning Probes
Nanomechanics
Laser Optics
Microelectronics
15,000 ft²

Utilities, Storage Service Space
20,000 ft²

Integration Wing:
Class 1000 Clean Room
Flexible Fabrication
10,000 ft²

Total Space = 80,000 ft²

Building designs are being developed to optimize equipment use and maximize interactions between CINT users and capabilities.

Core Facility will have a broad range of fabrication and characterization tools

Fabrication Laboratory

- Thin film deposition
- Photolithography
- E-beam/Focused Ion Beam
- Wet & Dry etching

Characterization Lab

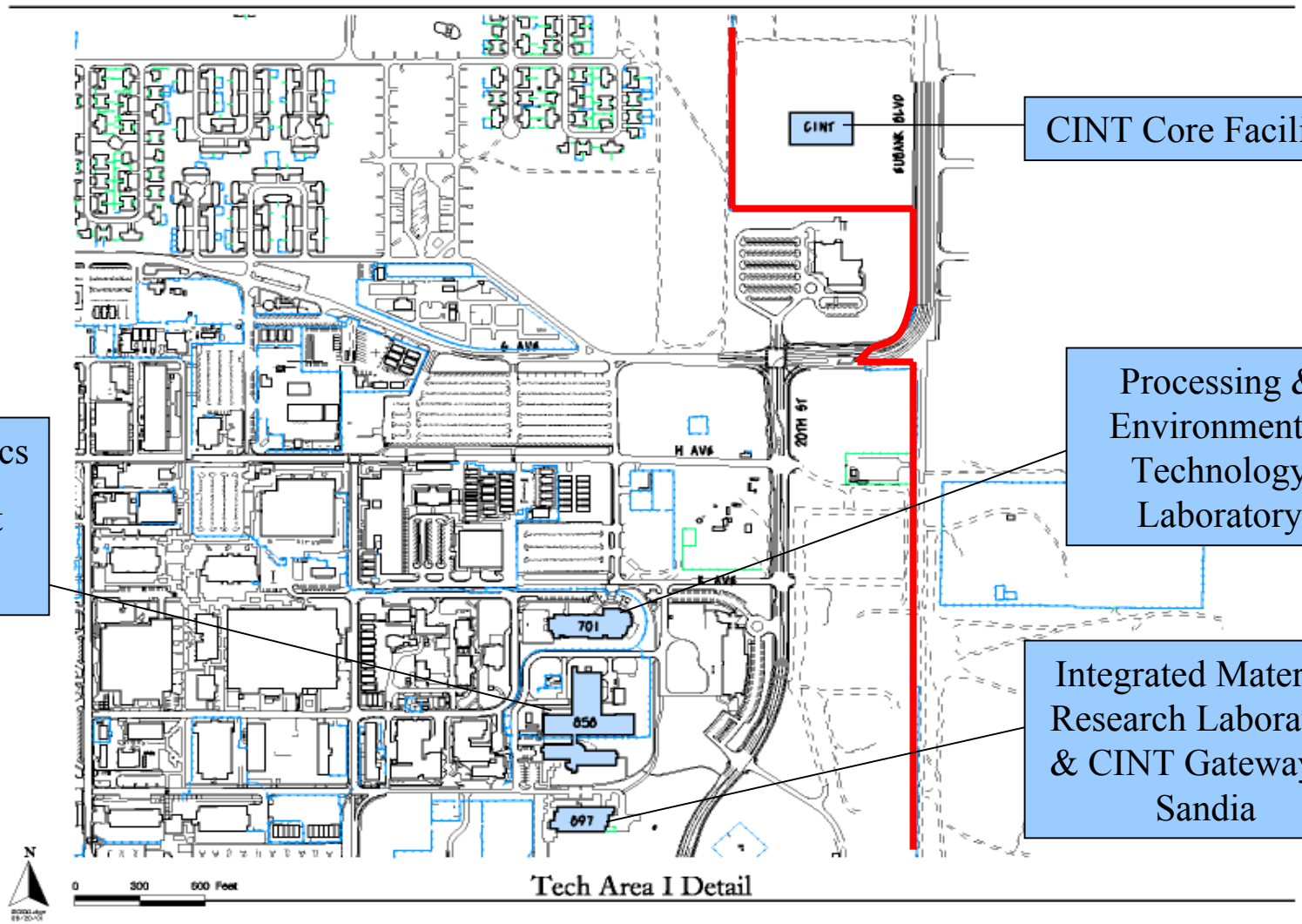
- SEM, SPM, OM
- Optical & electron spectroscopy

Interaction Area

- Conference/class rooms
- Video & ITV links

Some Pictures

CINT Core Facility will be located outside KAFB to ensure open access.



CINT Core Facility

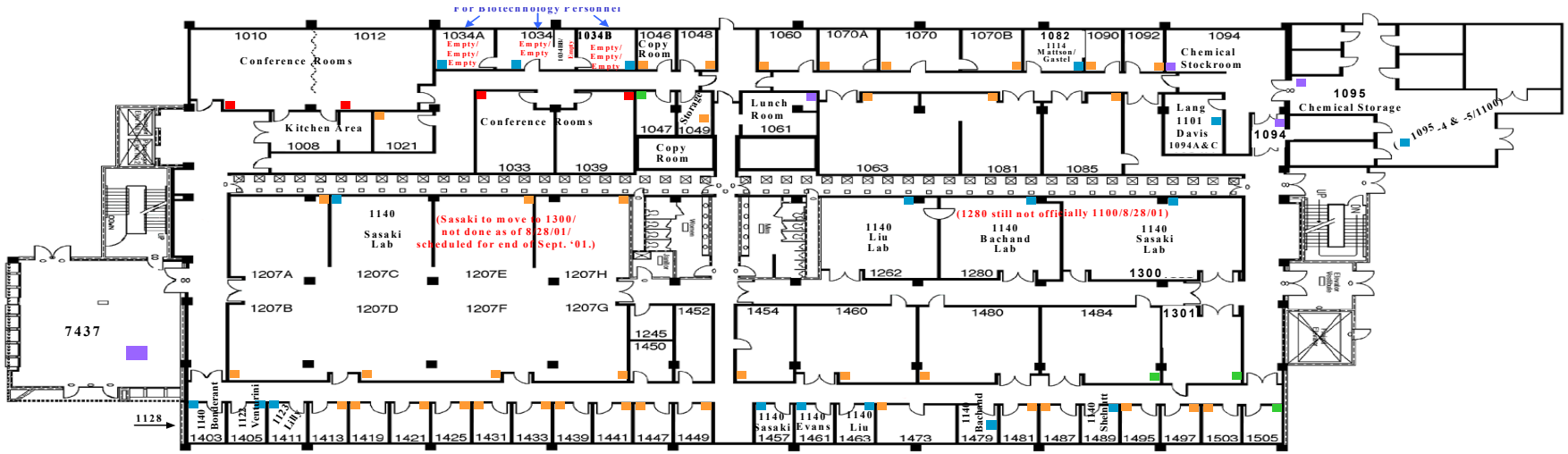
Processing & Environmental Technology Laboratory

Microelectronics Development Laboratory

Integrated Materials Research Laboratory & CINT Gateway at Sandia

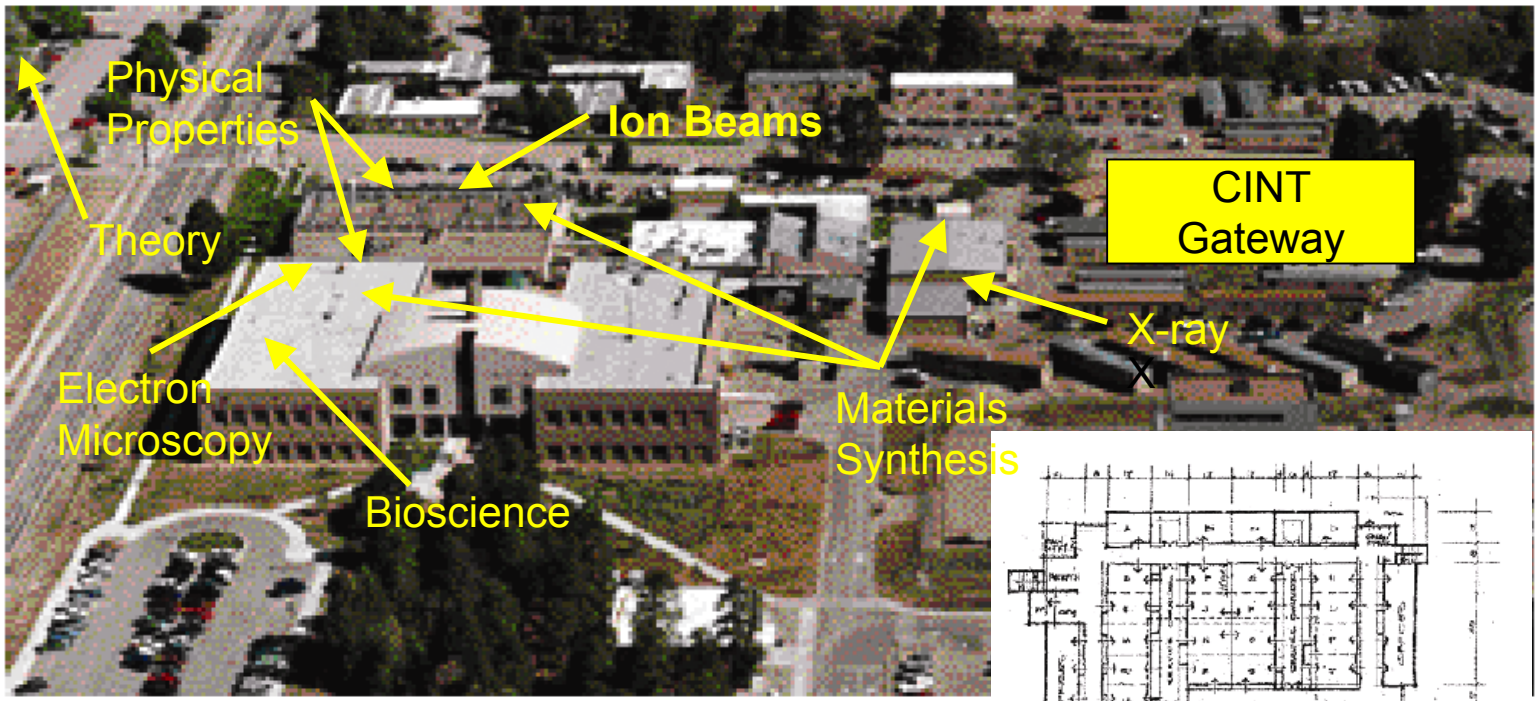
CINT Gateway to Sandia will focus on microfabrication and nanomaterials.

- Visitor Space
- Integrated fabrication
- Scanning probes
- MEMS/NEMS
- Theory
- High performance computing



CINT Gateway to Sandia will utilize existing space.

CINT Gateway to Los Alamos will focus on biosciences and nanomaterials.



- **staff, visitor offices – 3, 2000 sq-ft.**
- **synthesis and characterization – 14,000 sq-ft.**
- **interaction areas – 1, 5000 sq-ft.**
- **total – 30,000 sq-ft.**

CINT Gateway to Los Alamos will use combination of existing space and new construction

CINT collaborations extend across all research sectors

- **Universities**
  - CINT facilities will be a major national resource.
  - Postdocs, students and visiting faculty/ researchers comprise a major part of the CINT program.
  - Access will be provided at no cost, in collaboration with CINT researchers.
- **National and Federal Laboratories**
  - Other DOE NSRC facilities.
  - Federal laboratories: existing ties to AFRL, ARL, NIST, …
- **Industry**
  - Integrated nanotechnology and macroscopic functionality of critical interest to industry.
  - Scientific collaborations with industrial researchers.
  - Propriety research proposal mechanism.
- **International Science Community**
  - Open to the international science community

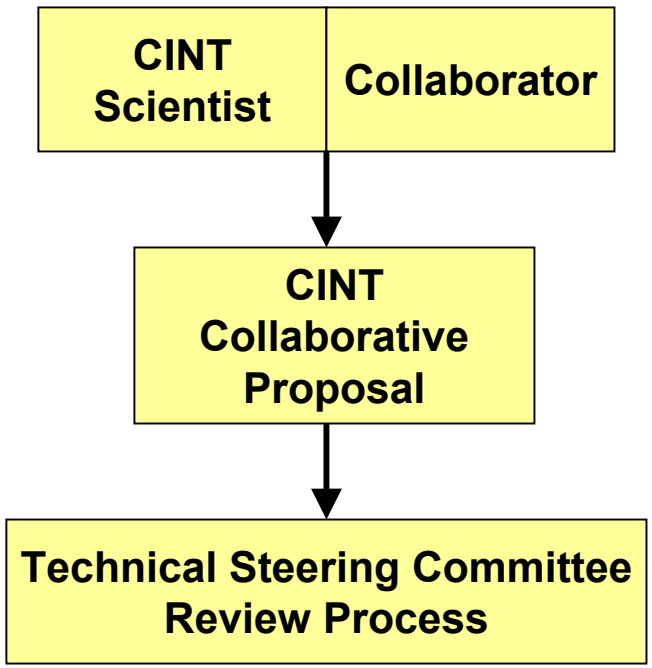
CINT collaborations will attract students and visiting scholars

- **Graduate Research Assistants** (~ 40)
  - Visiting students (short- and long-term) and CINT resident students (majority of thesis work at CINT)
  - Joint supervision by University faculty and CINT scientists
  - Financial support for travel/salary (as appropriate)
- **Undergraduate Interns**
  - Faculty advisor at home campus / CINT mentor
  - Largely summer experience
- **Postdoctoral Associates** (~ 40)
  - Internationally competitive research proposal based program
  - CINT scientists as mentors and champions
  - Full salary support and a research budget
- **Visiting Scholars**
  - University, industry, laboratory scientists on short- and long-term visits
  - Travel and local support provided as appropriate

Communications is a CINT priority

- **Workshops, symposia, and short courses**
  - Planning Workshop September 28-29, 2001
  - Developing with NTU a nationally televised seminar series
- **CINT News, a periodic newsletter will highlight significant research accomplishments.**
- **The CINT website will become a major resource for the nanotechnology community.**
- **The CINT Core Facility will be connected to CINT Gateways by high speed communications links.**

CINT Collaborator Interface

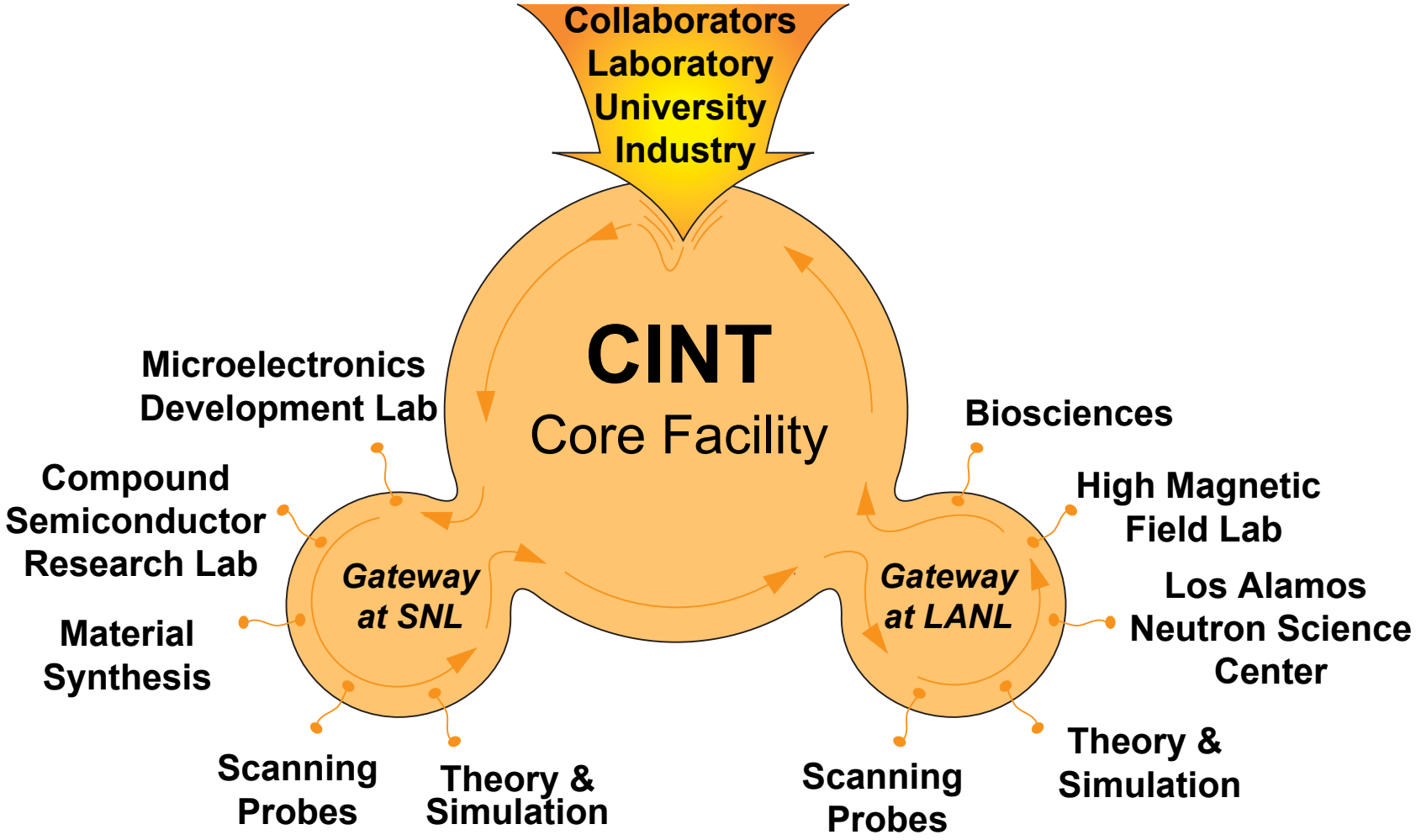


- science quality
- thrusts and programs
- proprietary proposal mechanism

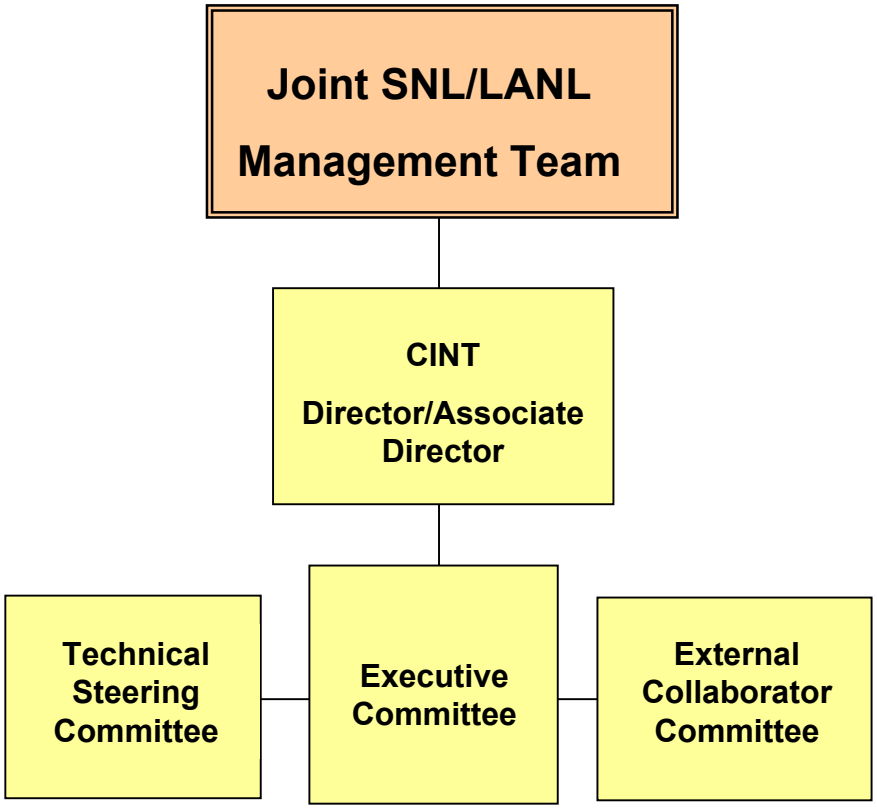
CINT collaboration opportunities developed through:

- CINT scientists
- Scientific meetings
- Scientific publications
- CINT Website
- CINT program announcements

Collaborations access entire CINT community

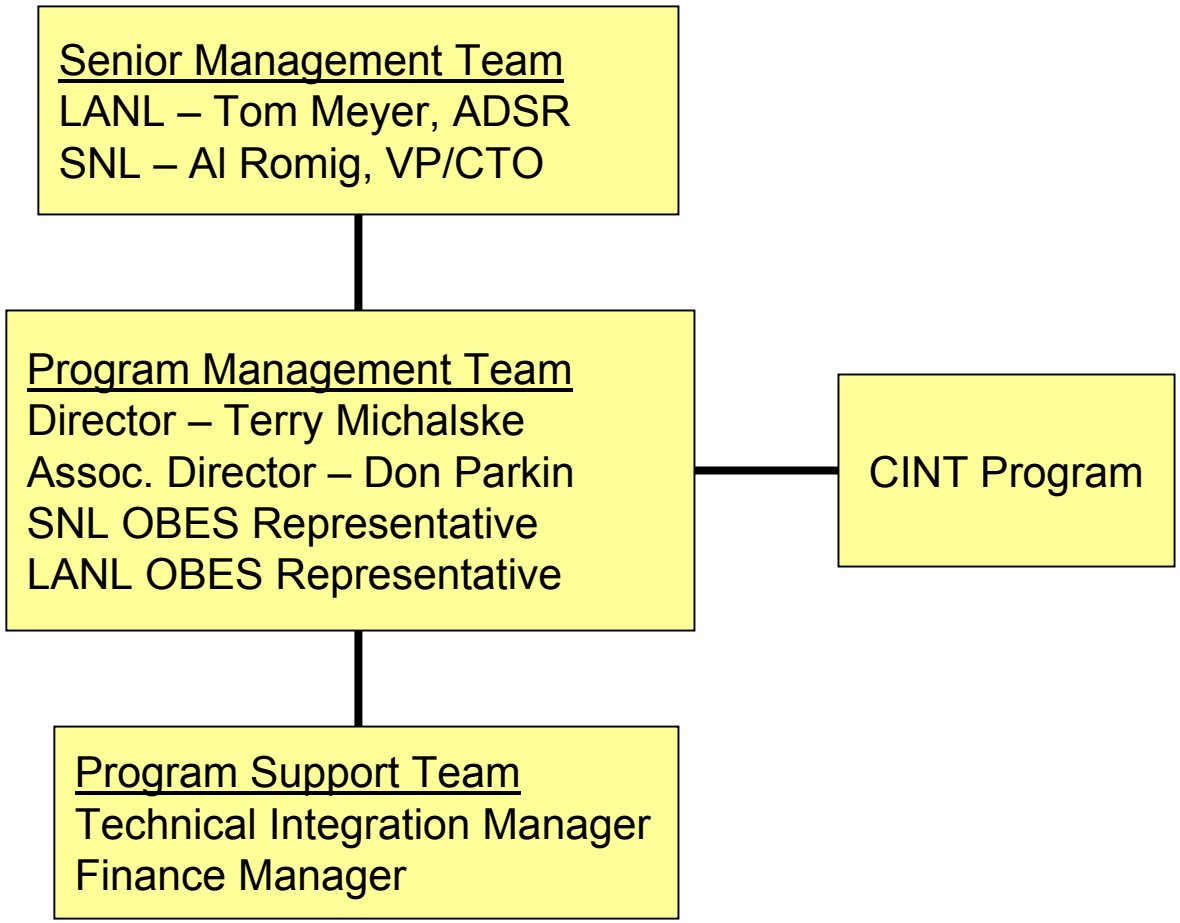


CINT Management Structure



- **Director and Executive Committee** – manage and coordinate CINT operations
- **Technical Steering Committee** – evaluate science opportunities, conduct proposal review process, recommend allocation of resources, develop collaborative and partnership mechanisms, appoint postdoctoral selection committee
- **External Collaborator Committee** – provide advice and guidance to Executive Committee

Joint National Laboratory Management



- **Senior Management Team monitor and review CINT scientific quality and mission performance**
- **Program Management Team responsible for CINT program success**
- **Program Support Team support PMT and coordinate Laboratory activities**

Internal and external scientists participate in the CINT Management Team

Director: Terry Michalske, interim
Associate Director: Don Parkin, interim

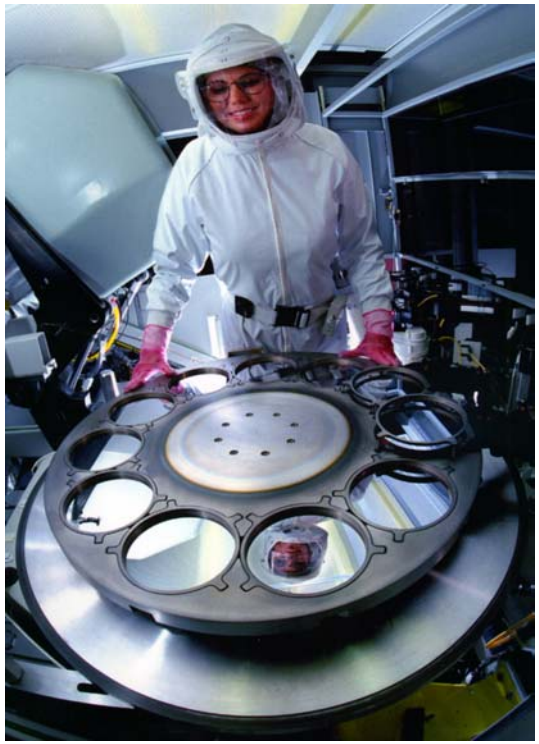
Program Management Team
- Director – Terry Michalske
- Assoc. Director – Don Parkin
- SNL OBES Representative
- LANL OBES Representative

CINT Executive Committee
- CINT Director
- CINT Associate Director
- LANL OBES Representative
- SNL OBES Representative
- Outreach Manager
- Construction/Operations Manager

Technical Steering Committee
- LANL BES Program Manager
- SNL BES Program Manager
- Scientific Thrust Leaders
- External Rotating Members

External Advisory Committee
- Industry Representatives
- Academic Representatives
- DOE Nanoscale Science Research Center (NSRC) Representative
- Other Nanoscience Center Representative
- National Science Foundation Representative

The CINT Community will have access to microfabrication, materials science, and computing resources at Sandia



Compound Semiconductor Research Lab (CSRL)

- 6,000 sq. ft. Class 100 clean room space
- extensive MOCVD and MBE epitaxial growth
- extensive fabrication facilities

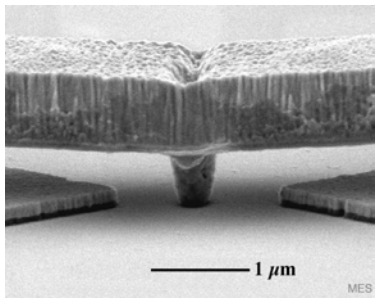
Microelectronics Development Lab (MDL)

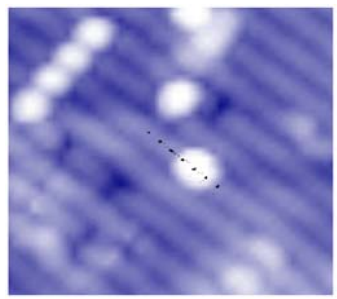
- 18,000 sq. ft. Class 100 clean room
- 12,000 sq. ft. Class 1
- foundry for CMOS, MEMS
- e-beam and ion-beam writing

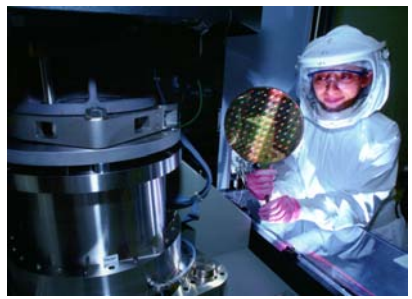
Integrated Materials Research Lab (IMRL)

- Scanning probes lab (IFM, atom tracker)
- Organic/inorganic synthesis

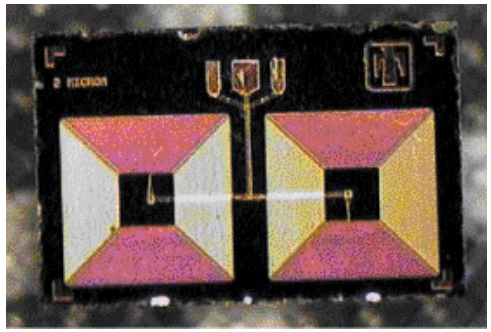
Teraflop computing platforms

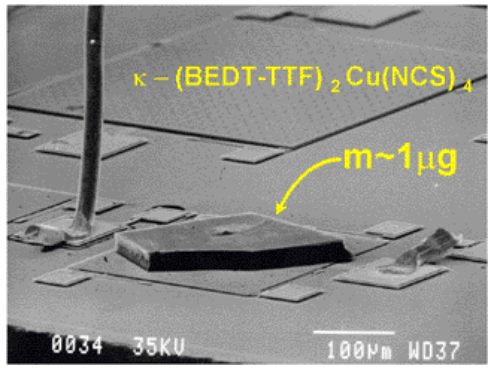






The CINT Community will have access to biosciences, materials science and computing resources at Los Alamos





NIRVANA Blue teraflop computer

Los Alamos Gateway Laboratories

Theory laboratory
- workstations, high speed links, HP-computing

Synthesis laboratories
- nanocell complexes, membranes

Characterization laboratories
- MRFM, AFM, SEM, low-temp & ultra fast STM
- femtosec spectroscopies, nanomechanical

Integration areas (conference rooms, video links)

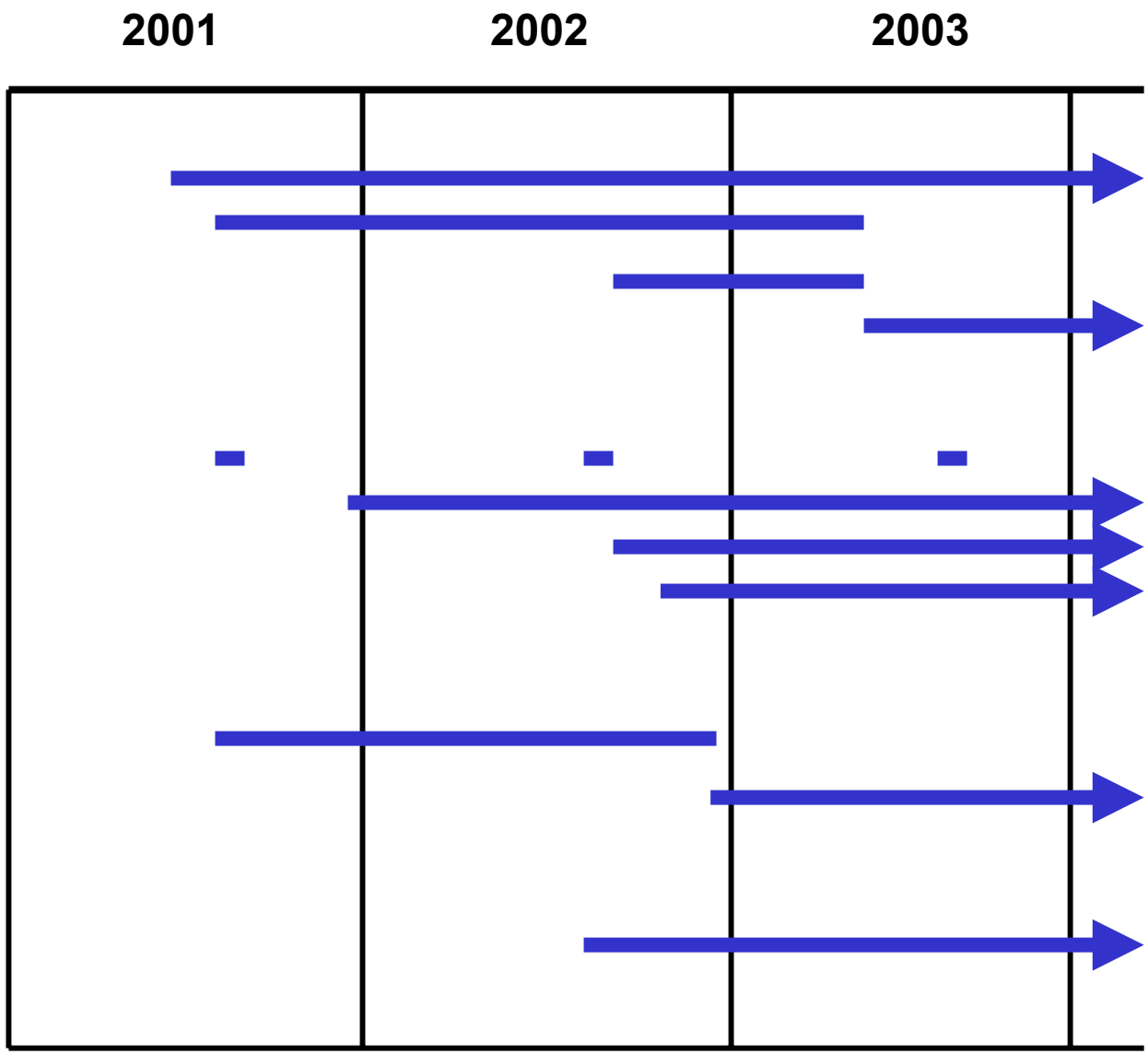
Optimize use of national user facilities

Advanced crystal growth techniques to prepare high quality crystals for the national nanoscale science research community

Support development of new instrumentation

Facilitate use of LANSCE and NHMFL for nanoscale science research

CINT Development Timeline



Management
- Joint Laboratory Team
- Interim Management
- National Director Search
- Permanent Director

Outreach
- CINT Workshops
  - Web Site
  - Newsletter
  - NTU Seminar

Construction
- Functional planning
- Design/Construction

CINT Programs
CINT Operations